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G2J JGDB

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EP 0187467 A1 EP 0171615 A2

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(54) Intergrated optical circuit having detector and optical fibre

(57) An integrated optical circuit has a detector 30 disposed with its photosensitive zone 32 approximately parallel to the end face of the detector end of an optical fibre 24. The detector 30 and the optical fibre 24 are both supported in a substrate 45. The optical fibre 24 is supported in aligning groove 11. Waveguide 46, recess 13, perforation 21, integrated circuit 40, circuit contacts 41 and chip contacts 31 are shown.

FIG. 3

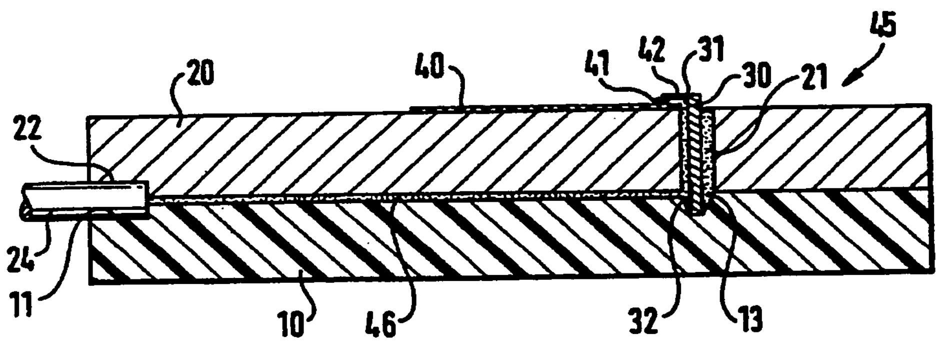

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FIG. 1

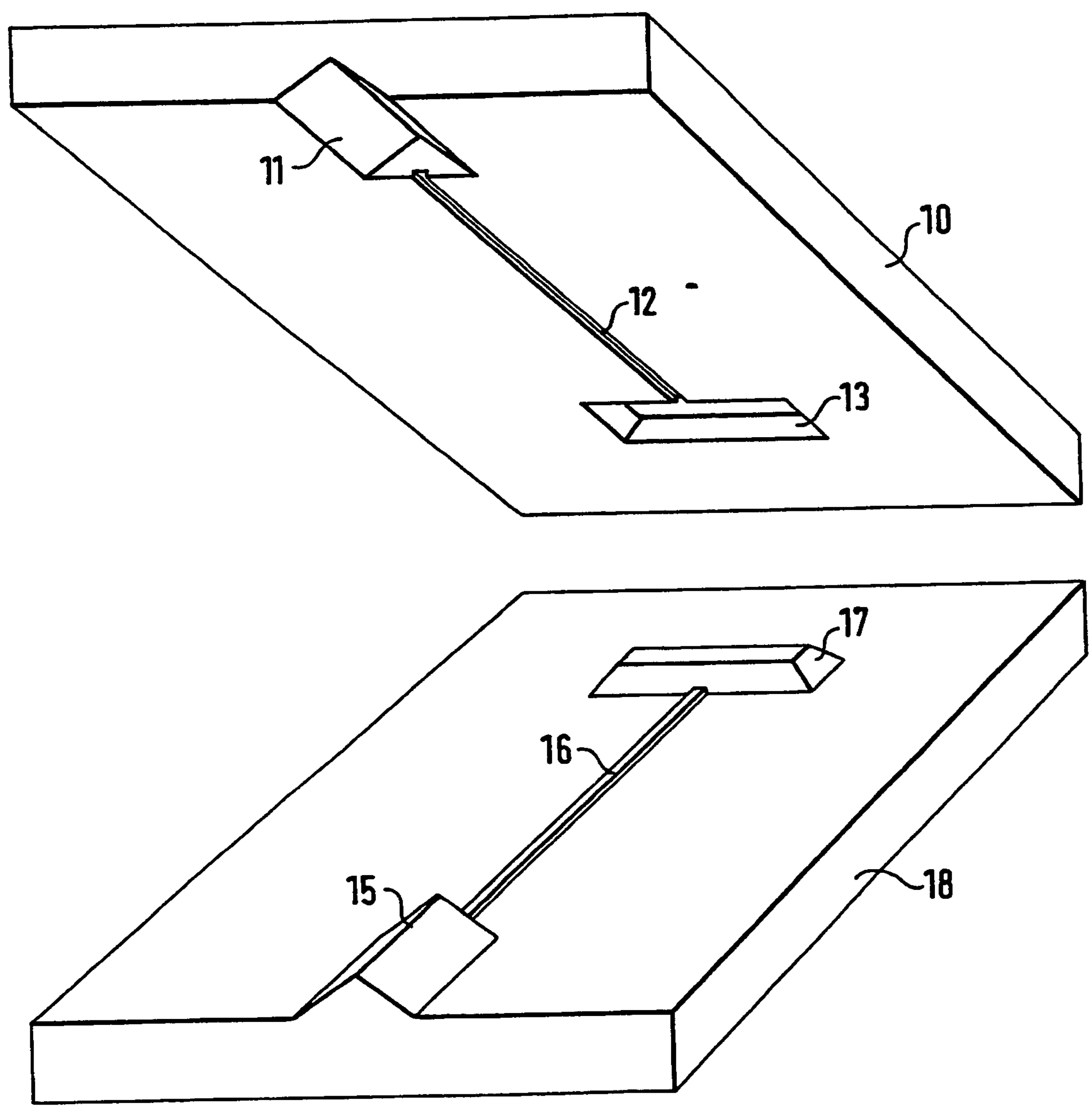


FIG. 2

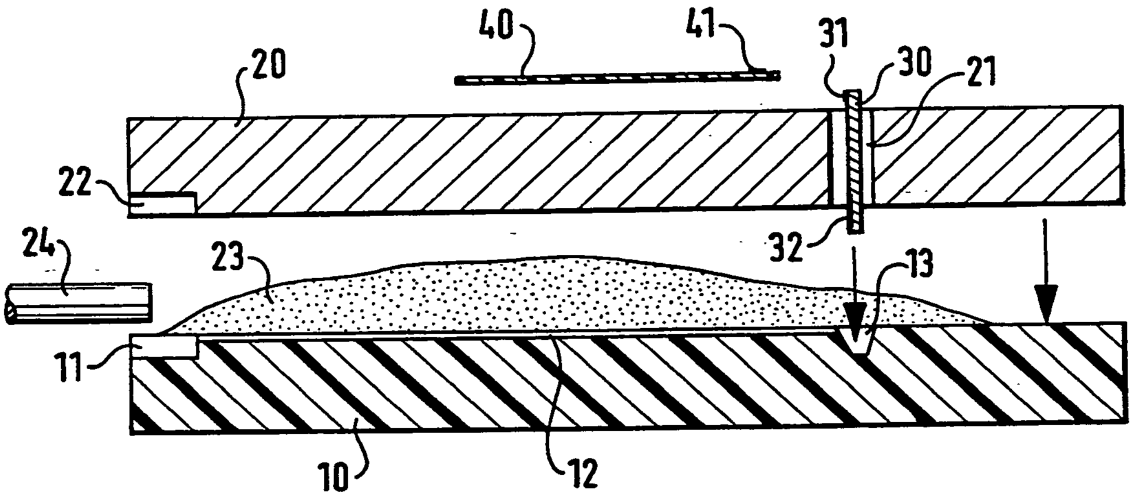
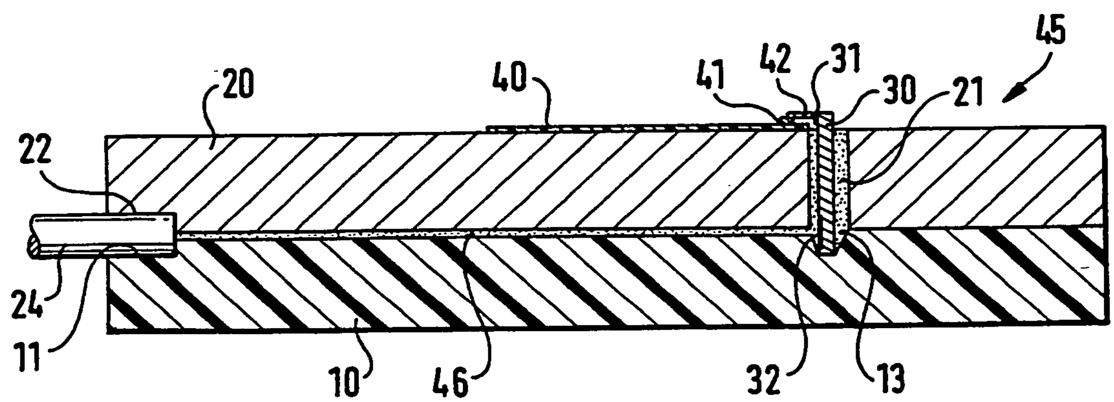

40
41
31
30
21
20
22
24
23
32
13
11
10
12

FIG. 3


45
40
41
42
31
30
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46
32
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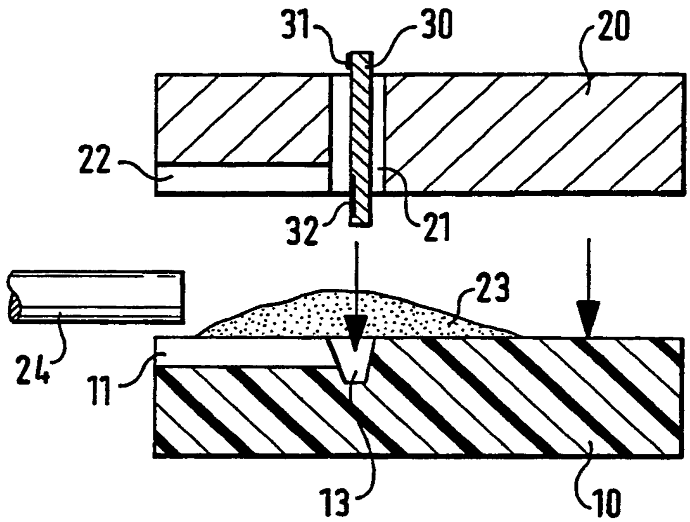
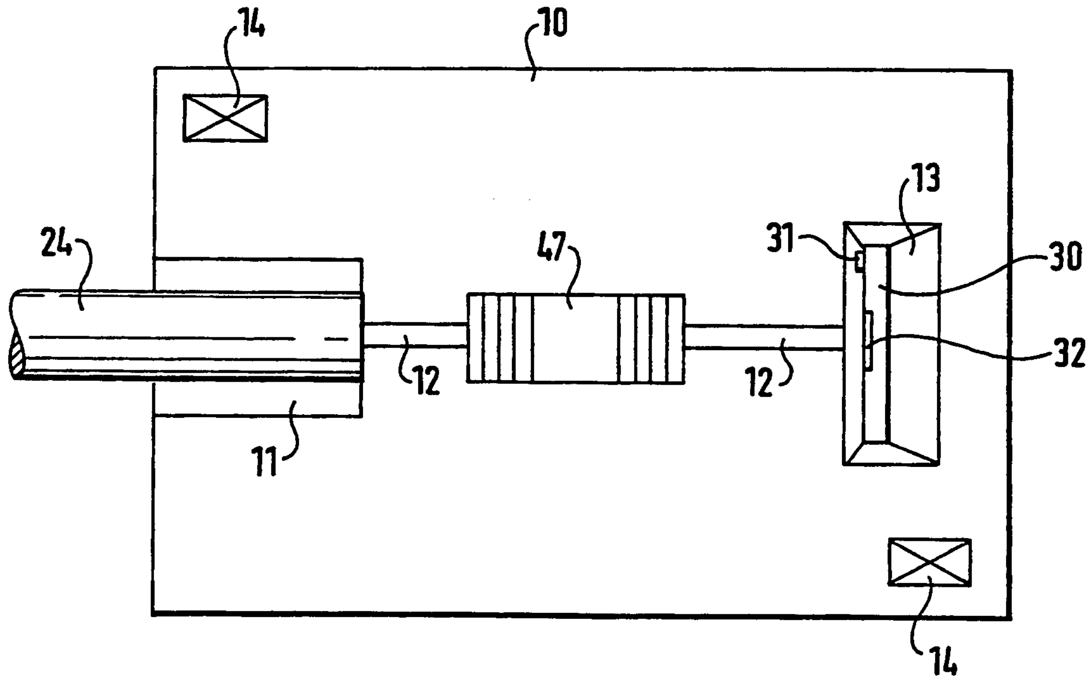


FIG. 4

FIG. 5



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Integrated optical circuit

Prior art

The invention proceeds from an integrated optical circuit according to the generic species of the main claim. The non-prepublished German Patent Application P 42 40 950.0 describes an integrated optical circuit in which a detector chip is encapsulated in a polymeric cover. A circuit base section composed of a polymer has a waveguide, with whose longitudinal axis the detector chip is parallel when the polymeric cover is placed on the base section. The light conducted in the waveguide is detected in this case by evanescent coupling. For this purpose, it is necessary for the detector to have a great length and a small width. This in turn necessitates a high accuracy in the alignment of the polymeric cover with respect to the base section. The coupling-out efficiency is relatively low in the case of evanescent coupling.

Advantages of the invention

In contrast, the integrated optical circuit according to the invention having the characterizing features of the main claim has the advantage that a higher coupling efficiency can be achieved. In addition, a higher tolerance is permitted for the alignment of the detector relative to the waveguide.

Advantageous further developments and improvements of the integrated optical circuit specified in the main claim are possible as a result of the measures cited in the subclaims.

It is particularly advantageous to provide, between the optical fibre and the detector, a waveguide which is embedded in the substrate since the latter can have any desired shape, even a curved shape, in the substrate, as a result of which a greater design latitude is available for the arrangement of the detector. In particular, the waveguide is suitable for feeding the conducted optical signal to a further integrated optical circuit situated between optical fibre and detector.

The construction of the waveguide as a groove filled with adhesive provides the advantage that the waveguide can be produced simultaneously with the mounting of the optical fibre in the substrate. As a result, one processing step becomes unnecessary in the production of the integrated optical circuit.

A further advantageous measure is provided if at least one optical component is disposed in the path of the optical signal between optical fibre and the detector since a processing of the optical signal upstream of the detector is thereby possible.

A further advantage is provided by the fact that the detector is embedded in the substrate, since a compact design of the integrated optical circuit can consequently be achieved and the detector is simultaneously protected from harmful environmental influences.

In addition, the advantage is also gained that the detector can be brought to the desired position without additional, in particular active, aligning aids if it can be aligned in the substrate by means of a passive aligning device.

The mounting of the detector in the substrate by means of an adhesive is a particularly simple and low-cost

implementation of the supporting of the detector in the substrate.

The siting of the connecting contacts of the detector outside the substrate serves the simple accessibility of said connecting contacts, as a result of which the expenditure on the electrical side of the integrated optical circuit is advantageously reduced.

The supplementing of the integrated optical circuit with a semiconductor circuit on the substrate results in the advantage that a further processing of the electronic signals of the detector can be carried out at the integrated optical circuit itself, which also keeps the space requirement of the integrated optical circuit advantageously low. In addition, as a result of the combination of integrated optical circuit and semiconductor circuit, the high-frequency serviceability of the arrangement can be improved, since only very short connections have to be provided between the two circuits.

The subdivision of the substrate into a cover and a base section with mutually matching aligning elements in each case provides the advantage that an alignment during the assembly of the integrated optical circuit is simplified.

Drawing

Exemplary embodiments are shown in the drawing and explained in greater detail in the description below.

In the drawing:

Figure 1 shows a moulding die with a base section moulded therefrom,

Figure 2 shows an exploded view of the integrated optical circuit in side view,

Figure 3 shows the integrated optical circuit in a first embodiment,

Figure 4 shows the integrated optical circuit in a second embodiment,

Figure 5 shows the base section of the integrated optical circuit with optical fibre and detector in plan view.

Description of the exemplary embodiments

Figure 1 shows a moulding die 18 which serves as female mould in the production of a base section 10. The square-shaped moulding die 18 has, at one edge of its top side a roof-ridge-shaped elevation 15 and a square-shaped elevation 16 whose longest axis is aligned with the ridge line of the roof-ridge-shaped elevation 15. The square-shaped elevation 16 directly adjoins the roof-ridge-shaped elevation 15. Disposed at the other end of the square-shaped elevation 16 is a truncated pyramidal elevation 17, which also directly adjoins the square-shaped elevation 16. The base section 10 is also square-shaped and has a roof-ridge-shaped recess 11 which corresponds to the roof-ridge-shaped elevation 15, a square-shaped recess 12 corresponding to the square-shaped elevation 16, and a truncated pyramidal recess 13 corresponding to the truncated pyramidal elevation 17.

To produce the base section 10, the moulding die 18 is preferably produced from nickel and can therefore serve as female mould for moulding a plurality of base sections 10. The base section 10 is produced by casting a liquid monomer, for example MMA, onto the moulding die 18 and crosslinking it to form the polymer. After being lifted off and

deburred, a finished base section 10 is available. The further use of the base section 10 is described in conjunction with Figure 2.

Figure 2 shows an exploded view of the integrated optical circuit in a side view. Here the base section 10 again has the roof-ridge-shaped recess 11, the square-shaped recess 12 and the truncated pyramidal recess 13. Furthermore, a cover 20 is shown which has the same external dimensions as the base section 10 and a roof-ridge-shaped upper aligning groove 22 which matches the roof-ridge-shaped recess 11 in the base section 10 and comes to rest above the latter when the cover 20 is placed on base section 10. The cover 20 furthermore has a perforation 21 which comes to rest above the truncated pyramidal recess 13. During the assembly, the end of an optical fibre 24 is inserted into the two roof-ridge-shaped recesses 11, 22. Disposed in the perforation 21 is a flat, square-shaped detector chip 30 which has a photosensitive zone 32 at its side facing the optical fibre 24. In addition, the detector chip 30 also has chip contacts 31 on the same side. In the gap between cover 20 and base section 10 there is an adhesive 23. On the top side of the cover 20 there is, in addition, an integrated circuit 40 having circuit contacts 41.

The adhesive 23 is preferably a transparent, curing polymeric adhesive whose refractive index is somewhat higher than that of the polymer material of the cover 20 and of the base 10. When the cover 20 and the base section 10 are assembled, the adhesive 23 is forced into the recesses 11, 22, 12, 13 and into the perforation 21, as a result of which a mechanically strong and stable joint is simultaneously produced between cover 20, base section 10, optical fibre 24 and detector chip 30. In addition, the adhesive 23 forms a waveguide 46 in the square-shaped recess 12 (see Figure 3).

Figure 3 shows the finally assembled integrated optical circuit. In this figure, the optical fibre 24 debouches coaxially into the waveguide 46, whose opposite end is situated precisely in front of the photosensitive zone 32 of the detector chip 30. In addition, the integrated circuit 40 is mounted on the top side of the cover part 20 and its circuit contacts 41 are connected to the chip contacts 31 of the detector chip 30 via electrically conducting connections 42. Base section 10 and cover 20 together form a substrate 45.

The detector chip 30 is consequently supported in the substrate 45, light conducted by the optical fibre 24 being fed in the form of an optical signal via the waveguide 46 to the photosensitive zone 32, whose electrical signals are fed to the integrated circuit 40 via the chip contacts 31. The assembly is ideally carried out in such a way that the detector chip 30 is placed in the truncated pyramidal recess 13 after the application of the adhesive 23 to the base section 10, an automatic, passive alignment of the detector chip 30 taking place as a result of the truncated pyramidal shape. As a result of the viscosity of the adhesive 23, the detector chip 30 undergoes in this case a slight stabilization in its position. This stabilization is sufficient to guide the detector chip 30 through the perforation 21 when the cover 20 is mounted. As a result of the displacement of the adhesive 23, the perforation 21 then also fills with adhesive, as a result of which a further stabilization of the position of the detector chip 30 takes place. The detector chip 30 acquires a final stabilization after the curing of the adhesive 23. However, provision is also made for first joining the cover 20 and base section 10 to the optical fibre 24 and then placing the detector chip 30 in the perforation 21. Normally, a polymer which can be cured by means of UV light is used for the adhesive 23 so that a mechanically stable joint of all the components takes

place as a result of suitable exposure after inserting the detector chip 30.

Figure 4 shows a further development of the integrated optical circuit. In this figure, identical numerals denote identical elements. The arrangement shown differs from the arrangement shown in Figure 2 in that the square-shaped recess 12 is omitted. In this case, the photosensitive zone 32 of the detector chip 30 is coupled directly to the optical fibre 24. This results in a space-saving design which can be implemented at particularly low cost and which, moreover, yields a particularly low-loss coupling between detector chip 30 and optical fibre 24.

Figure 5 shows the plan view of a further embodiment of the integrated circuit. For the sake of clarity, the cover 20 and the adhesive 23 were not shown in this case. The optical fibre 24 is again situated in the roof-ridge-shaped recess 11 in the base section 10. The surface of the base section 10 is provided with a structure corresponding to an optical Bragg resonator 47 in the path of the square-shaped recess 12. The Bragg resonator 47 is used here for filtering, since only those light components of the optical signal are allowed through the Bragg resonator which correspond to the resonance frequency of the Bragg resonator 47. Thus, a frequency-selective detection of optical signals is possible. In addition, the base section 10 has two pyramidal elevations 14 whose equivalent must be disposed in the cover 20 in the form of pyramidal recesses. This facilitates the alignment of the cover 20 on the base section 10 during assembly. Provision is also made for disposing a further integrated optical circuit between optical fibre 24 and the detector chip 30 in the path of the waveguide 46. Optical gate circuits or filter circuits, for example, are suitable as a further integrated optical circuit.

Claims

1. Integrated optical circuit having a detector which receives an optical signal and has a photosensitive zone, and having an optical fibre which conducts the optical signal to the detector and which is supported in a substrate at its detector end by means of at least one aligning groove, characterized in that the photosensitive zone (32) of the detector (30) is approximately parallel to the end face of the detector end of the optical fibre (24) and in that the detector (30) is supported by the substrate (45).

2. Integrated optical circuit according to Claim 1, characterized in that there is provided, between the end face of the detector end of the optical fibre (24) and the photosensitive zone (32), a waveguide (46) which is embedded in the substrate (45) and whose longitudinal axis is aligned with the longitudinal axis of the optical fibre (24).

3. Integrated optical circuit according to Claim 2, characterized in that the waveguide (46) is a groove (12) filled with a transparent, curable adhesive (23).

4. Integrated optical circuit according to one of Claims 1 to 3, characterized in that at least one optical component (47), preferably a wavelength-selective filter or a further integrated optical circuit, is disposed in the path of the optical signal between the end face of the detector end of the optical fibre (24) and the photosensitive zone (32).

5. Integrated optical circuit according to one of Claims 1 to 4, characterized in that the detector (30) is embedded in the substrate (45).

6. Integrated optical circuit according to one of Claims 1 to 5, characterized in that the position of the detector (30) can be aligned by means of a passive aligning device (13) disposed on the substrate.

7. Integrated optical circuit according to one of Claims 1 to 6, characterized in that the detector (30) is mounted on the substrate (45) by means of an adhesive (23).

8. Integrated optical circuit according to one of Claims 1 to 7, characterized in that the detector (30) has connecting contacts (31) which are situated outside the substrate (45).

9. Integrated optical circuit according to Claim 8, characterized in that there is supported on the substrate (45) an electronic circuit (40), preferably a semiconductor circuit, which has circuit contacts (41) which are connected to the connecting contacts (31).

10. Integrated optical circuit according to one of Claims 1 to 9, characterized in that the substrate (45) comprises a cover (20) and a base section (10) and in that cover (20) and base section (10) have aligning elements (14) which each match one another and which facilitate a precisely fitting placing of the cover (20) and of the base section (10) on one another.

11. Any of the integrated optical circuits substantially as herein described with reference to the accompanying drawings.

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Patents Act 1977
Examiner's report to the Co[redacted]oller under Section 17
(The Search report)

Application number
G[redacted]04786.6

Relevant Technical Fields

(i) UK Cl (Ed.N) G2J (JGDB)

(ii) Int Cl (Ed.6) G02B

Databases (see below)
(i) UK Patent Office collections of GB, EP, WO and US patent specifications.

(ii)

Search Examiner
MR C ROSS

Date of completion of Search
26 APRIL 1995

Documents considered relevant following a search in respect of Claims :-
1-11

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages	Relevant to claim(s)
X	EP 0171615 A2 (N.T.&T.) see especially Figure 7	1 at lesat
X	EP 0187467 A1 (CORNING) see especially Figure 8	1 at least

Databases: The UK Patent Office database comprises classified collections of GB, EP, WO and US patent specifications as outlined periodically in the Official Journal (Patents). The on-line databases considered for search are also listed periodically in the Official Journal (Patents).

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